HUXLEY LIBRARY
SML
WITHDRAWN
LONDON
C.7.230

CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER

PUBLICATIONS DE CIRCONSTANCE

N° 39

Cupboard
Shelf
Box 85

MARTIN KNUDSEN

SOME REMARKS ABOUT THE CURRENTS IN THE NORTH SEA AND ADJACENT WATERS

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

JUIN 1907

CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER

PUBLICATIONS DE CIRCONSTANCE

N° 39

MARTIN KNUDSEN

SOME REMARKS ABOUT THE CURRENTS IN THE NORTH SEA AND ADJACENT WATERS

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

JUIN 1907

COPENHAGUE — IMPRIMERIE BIANCO LUNO

SOME REMARKS ABOUT THE CURRENTS IN THE NORTH SEA AND ADJACENT WATERS

BY

MARTIN KNUDSEN

It is a well-known fact that the North Sea gets a supply of salt Atlantic water, partly from the north partly through the English Channel. Along the coasts stretches a border of fresher water produced by the fresh-water supply from land; the charts and sections showing the mean salinities at the various places[1]) give a representation of the proportional volume of the various water supplies, as well as of the intensity of mixture in the different parts.

As to the surface-water, we see that the isohalines bend southward into the North Sea; the 35,1 ‰- and 35,2 ‰-isohalines reach their southermost positions near the 0°-meridian, at a distance from the Scottish coast equal to about 90 miles, that is to say about half the distance from the Norwegian coast. We thus see that the water-masses streaming between Scotland and the Shetlands into the North Sea by no means consist of undiluted Atlantic water, but that the coast water must constitute a considerable portion of this inflow.

This coast water comes partly from the Scottish west coast, partly from more southerly regions viz. the waters around Ireland, especially those of the Irish Sea. In hydrographical respects, the Irish Sea forms a separate area with strongly marked tidal currents which cause an intense mixing up of the Atlantic water with the fresh water coming from the rainy regions of England and Ireland. The Irish Sea is thus characterized by being filled from the bottom to the surface with water of nearly the same salinity, the mean value of this salinity at the various places being about 34,4 ‰.

A considerable part of these water-masses gets into the North Sea; a proportionally small part streams by jerks through the English

[1]) Martin Knudsen and Miss Kirstine Smith, The Salinity of the North Sea and Adjacent Waters Calculated on the Basis of Observations from the Period August 1902—May 1905. Conseil Permanent International pour l'Exploration de la Mer: Rapports et Procès-Verbaux des Réunions. Vol. VI. 1906. p. XXVI.

Channel, by far the greatest part streams northward around Scotland as a more steady and continued stream. The waters moving northward from the Irish Sea are joined by the diluted Atlantic water from the Scottish west coast which also streams round Scotland into the North Sea.

JOHAN GEHRKE has calculated the mean velocity of the current north of Scotland[1]) to be 4,4 miles in 24 hours = about $9^1/_2$ cm. per sec. Maintaining this velocity continually, a water-particle will move from the Irish Sea (North Channel) to the Channel between Scotland and the Shetlands in 80 days. The water-volume yearly leaving the Irish Sea when deduced by means of MARTIN KNUDSEN's hydrographical theorem, may approximately be regarded as at least equal to the water-volume contained in the entire Irish Sea, that is to say about 3000 cubic-kilometers. As already mentioned, a very considerable part of this water gets into the North Sea, and we may thus expect that the flora and fauna of the Irish Sea may have a certain influence upon those of the North Sea; and when studying the salinity-variations in the north-western part of the North Sea, it is quite necessary to take this inflow into account.

The mixed waters from the Irish Sea and from the Scottish west coast again get mixed with Atlantic water when passing north around Scotland and between Scotland and the Shetlands, owing to the proportionally small depths in these areas and the exceedingly strong tidal currents occurring here. The consequence is that the diluted waters get an increased salinity in the areas near the coasts, but a diminished salinity in the regions farther from land. Owing to this fact, the 34,7 ‰- and 34,9 ‰-isohalines run very close to the Scottish coast, while the 35,2 ‰-isohaline withdraws to a considerable distance from this coast.

If we take a water-particle lying in the 35,2 ‰-isohaline NW of Scotland, this particle will get its salinity diminished as it moves towards the north-east. Consequently the current must have a component perpendicular to the isohalines and directed towards the lesser salinities. The water-particle must therefore during its motion withdraw farther and farther from the isohaline in the direction towards land, and as the 35,2 ‰-isohaline east of Scotland bends considerably down into the North Sea we may thus state that the whole water-volume passing between the Scottish north coast and the 35,2 ‰-isohaline-surface will get into the North Sea. JOHAN GEHRKE has shown[1]) that a water-volume of about 61000 cubic-kilometers yearly streams through a section drawn from Dunnet

[1]) JOHAN GEHRKE, Mean Velocity of the Atlantic Current North of Scotland and through the Channel. Publications de Circonstance. No. 40.

Head in a north-westerly direction to the region where the mean salinity reaches its maximum 35,33 ‰. The part of this section lying within the 35,2 ‰-isohaline will by measurements in the section be found equal to $^4/_{10}$ of the whole section. Thus the entire water-volume entering the North Sea from these regions can be calculated at **25000** cubic-kilometers. In the channel between Scotland and the Shetlands the current attains its greatest velocity. It can easily be shown that this velocity is more than 1,4 times the speed in the former section, that is to say, greater than 6,2 miles in 24 hours = $13^1/_2$ cm. per sec. The total water-volume contained in the North Sea with the Skager Rak and Cattegat, limited by Dover-Calais and Scotland-Shetland-Bergen, is about 50000 cubic-kilometers (the mean depth being estimated at 90 meters, the surface area 58×10^4 square-kilometers). Consequently it is seen that the water-volume streaming into the North Sea around the north of Scotland in the course of two years would be able to renew almost entirely the whole water-contents of the North Sea. Yet it is to be noticed that the main part of these water-masses only penetrate a short way into the North Sea and then are washed out again by the out-going stream in the eastern areas of the North Sea. Also north of the Shetlands a water-supply takes place to the North Sea, partly as a surface-current, but mainly at depths of more than 100 meters. As to the volume and velocity of the water-masses, this inflow cannot compete with the above mentioned stream coming from the west in the upper layers. But it is of considerable importance just owing to the fact that the inflow takes place by jerks and the mixing process proceeds so slowly that the ingoing water-masses for a long space of time can keep their physical qualities almost unaltered, thus producing the peculiar hydrographical conditions found in the bottom waters of the deep areas in the northern part of the North Sea[1]).

The waters coming through the Scotland-Shetland-Strait and streaming southward into the North Sea get a further fresh-water supply from the Scottish and English east coast, and a strong mixing process is called forth by the strong tidal currents.

Through the English Channel the North Sea also receives Atlantic water which is often mixed with water from the Bay of Biscay or from the Irish Sea. This water is on both sides bordered by diluted water produced under the influence of the rivers falling into the Channel. The mixing is exceedingly thorough owing to the strong tidal currents; but notwithstanding these facts the inflow is sufficiently powerful to bend the isohalines far into the Channel; the 35,1 ‰- and the 35,0 ‰-isohalines even stretch a long way into the

[1]) See: Report from the North Sea Fisheries Investigation Committee (Northern Area). 1902—1903. London, 1905.

North Sea. From the Channel the North Sea thus receives some diluted water and some only slightly diluted Atlantic water. We get an idea of the volume of the last named water-masses in proportion to the Atlantic inflow coming from the north, by fixing the position of the point where the saltest water coming from the north and the saltest water coming from the south yield equal contributions to the raising of the salinity. The mean salinity charts already cited make it evident that the point sought for lies south of the Dogger Bank at 54° N Lat. 3° E Long., that is to say in the southern part of the North Sea.

Although it thus has been stated that the volume of the inflow through the Channel cannot compete with the stream coming from the north, yet the former is of decisive importance for the hydrographical conditions in the southern part of the North Sea. The 35,2 ‰-isohaline reaches 51° N Lat. (that is to say the latitude of Dover-Strait), while the 35,0 ‰-isohaline continues 2° further northward and reaches 53° N Lat. (= the latitude of Helder). In moving from Dover-Strait to the latitude of Helder the salinity is consequently only diminished 0,2 ‰, and in the absence of more detailed information, we may suppose that the fresh-waters from both coasts have equal shares in this reduction. The salinity of the waters close to the Belgian-Dutch coast is less than 34 ‰ (see the salinity-charts), and the heart of current in the latitude of Helder may therefore be regarded as consisting of Channel-water mixed up with less than 20 % coast water. Consequently the inflowing Channel-water may be considered as forming a barrier for the diluted waters coming from the north and for the salter but yet somewhat diluted Atlantic water in the central part of the North Sea.

By far the greatest part of the mixed water that flows southward along the English east coast, must consequently turn to the north of the inflowing Channel-water and its accompanying mixed waters. Owing to this circumstance the salt water from the Channel and the water-volumes lying between that and the Belgian-Dutch coast form a separate hydrographic region which only gets a comparatively slight water-supply from the other parts of the North Sea[1]). The western limit of the area where the Channel-water is of predominant influence, will by means of the charts be seen to lie close off the English coast as far northward as to Lowestoft. From here the limit runs up towards the southern part of the Dogger-Bank and then (at 3° E Long.) it turns towards the east.

[1]) Compare: P. J. van Breemen, Ueber das Vorkommen von Oithona nana Giesbr. in der Nordsee. Publications de Circonstance. No. 7. 1903.

The Dogger Bank itself is seen to lie in water having a mean salinity of 34,7—34,9 ‰. This water is a mixture of the Channel-water and the diluted water that comes from the north-west and partly is produced west of Great Britain, but mainly east of it. On the northern area of the Dogger-Bank, the Channel-water has certainly no appreciable influence, while on the southern area it must be supposed to have a considerable effect upon the conditions.

Comparing the mean salinity at the surface and at the bottom in the North Sea, we see that in the southern part south of 54° N Lat. the salinity is to be regarded as constant from surface to bottom. This result also holds good for the Dogger-Bank and the areas to the west and south of it. The fact is of great importance for future investigations, because we by merely investigating surface samples can determine the salinity of the whole water-volume with an accuracy sufficient for several purposes. The same can be said about almost the entire English Channel and the Irish Sea.

In those waters where the conditions have the said character, there are considerable differences between the salinities at the various places. Hence it may be deduced that the resulting streams must be about identical at the surface and in the deeper layers. Further, the currents can only have slight velocity-components perpendicular to the isohalines at such places where the isohalines lie close together; here the currents must mainly follow the direction of the isohalines. Consequently, south of the Dogger-Bank the central part of the Channel-stream can only have a slight velocity in a northerly direction compared with its velocity towards the east, as at this place the isohalines for 34,7 ‰, 34,8 ‰, 34,9 ‰ lie close together. The stream here (53½° N Lat.) meets the current coming from between west and north, is mixed with the waters coming from the west, and is turned in an easterly direction mainly following the shape of the continental coasts. Its waters are subject to a further dilution by the fresh-water supply from land, thus constituting a very broad border of mixed waters filling up the entire German Bight and stretching along the Jutland coast up towards the Skager Rak. Having received the considerable water masses from the Elbe, the mixed sea-waters only get slight fresh-water supplies on their passage towards the Skager Rak. The influence of the tidal currents gradually decreases the farther north we proceed; we therefore also find some difference, although only a proportionally slight one, between the salinities of the surface and bottom waters along the west coast of Jutland.

Digitized by the Internet Archive
in 2026

https://archive.org/details/ices-journal-of-marine-science_1907-06_39

NB. Une **LISTE DES PUBLICATIONS** du Conseil permanent international pour l'exploration de la mer, savoir:

Série A: Rapports et Procès-Verbaux des réunions

— B: Bulletin (trimestriel) des résultats acquis pendant les croisières périodiques etc.

— C: Publications de circonstance

— D: Bulletin statistique

a paru en Janvier 1907. Elle est envoyée **franco**, sur demande adressée à MM. **Andr. Fred. Høst et fils**, libraires à Copenhague.

COPENHAGUE - IMPRIMERIE BIANCO LUNO